237f Project Based Environmental Separations

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In 1987 the National Research Council released a report stating that, “The expanding world population is having a tremendous impact on our ecosystem, since the environment must ultimately accommodate all human derived waste materials. The industries that provide us with food, energy, and shelter also introduce pollutants into the air, water, and land. The potential for an increasing environmental impact will inevitably result in society's setting even lower allowable levels for pollutants. In the future, separation processes will be critical for environmental remediation and protection.” The environmental industry in the United States and worldwide is large and projected to grow at a substantial rate.

Chemical separations are used to reduce the quantity of potentially toxic or hazardous materials discharged to the environment. In addition, separations that lead to recovery, recycle, or reuse of materials, also known as P2 or pollution prevention, also prevent discharge, sometimes in an economically beneficial manner.

To address the need for expertise in environmental separations and engineering, elective courses are offered in environmental separations both in the Chemical Engineering program at the University of Colorado - Boulder (CUB) and in the Environmental Science program at the University of Wisconsin – Green Bay (UWGB). To address the need for environmentally specific situations, Professor Richard Noble (CUB) and Professor Patricia Terry (UWGB) co-authored a text, “Principles of Chemical Separations with Environmental Applications,” (Cambridge University Press, 2004) for these courses. The text begins with a review of the fundamental principles of unit operations, phase equilibrium, and mass balances. The authors then present distillation, extraction, absorption, adsorption, ion exchange, and membranes with applications to environmental challenges. In addition, bioremediation is included in the course at UWGB.

At UWGB, the lecture is enhanced by aqueous phase laboratory experiences demonstrating removal of suspended solids and Giardia using hollow fiber ultrafiltration/ microfiltration membranes, removal of hexavalent chromium, phosphates, and nitrates via ion exchange, and bioremediation of heavy metal contaminated water. In addition to demonstrations with these newer technologies, solid phase extraction is used to illustrate remediation of contaminated soils.

The city of Green Bay is located at the outflow of the Fox River into the bay of Green Bay, part of the Lake Michigan watershed. The Fox River stretches for approximately thirty miles south, along which lies a significant percentage of the U.S. paper industry. In addition, Green Bay and its surrounding area are home to metal plating industries, meat rendering plants, dairy and other agricultural industries, and industries supporting manufacture of paper and paper products. Each of these facilities is accompanied by its own set of environmental challenges.

To provide students the opportunity to apply environmental separations to real world challenges, the environmental separations course at UWGB is project based. Each student chooses an environmental problem and designs a separations system to remediate the pollutants of concern and/or design a system for pollution prevention. Some of these projects have involved students collecting laboratory data on proposed systems for membrane separations, ion exchange, and bioremediation. One year, a student's project even coincided with a pilot plant study applying ultrafiltration/microfiltration membranes to treatment of Lake Michigan water prior to discharge into the Green Bay water supply. Another student was involved with a dairy farm project applying anaerobic digestion to the bovine waste stream and collecting methane gas for energy production.

Newer technologies are more difficult to model mathematically than well established ones. The collection of real data allows students to better see how membrane separation, ion exchange, and bioremediation operate to purify water. This experience provides them with a basis for scale-up to an industrial level where applicable. Students are also able to measure the effect of various process parameters on the efficiency of removal and model stage processes in a batch mode.

Environmental separations are best taught by specific examples, both with a textbook specialized to the field and via hands on examples whenever possible. Applying classroom knowledge to real problems involving local industry is also highly beneficial in enhancing student comprehension.